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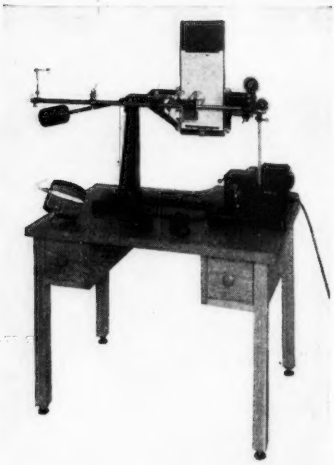

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Surface Characteristics of Cotton Fibers as Indicated by Electrophoretic Studies

By ARNOLD M. SOOKNE and MILTON HARRIS *

A Textile Foundation Publication

Abstract

Natural cotton is composed of a primary and a secondary wall. The former forms a thin sheath on the surface of the fiber and is composed principally of small amounts of cellulose imbedded in a membrane of wax and pectic substance. The latter is composed principally of cellulose and forms the main body of the fiber. The pectic substance, although present to the extent of only approximately 1 percent, accounts for 85 percent of the total acidic groups of the mature fiber. The highly acidic nature and the location of this substance in the naturally-occurring fibers would be expected to influence greatly a number of the properties of the fibers, especially those dependent on surface characteristics. These surface characteristics are of considerable importance in a number of industrial processes such as, for example, the scouring, dyeing, and finishing of textile materials.

Since the electrophoretic technique has been shown by research associates for the Textile Foundation at the National Bureau of Standards to be a useful tool for characterizing other fiber surfaces, it appeared advisable to apply it to an investigation of the cotton fiber as well. Samples of dewaxed cotton, cotton which had been depectinized by treatment with a boiling 1-percent solution of sodium hydroxide for various lengths of time, and pectic substance from cotton gave widely different pH-mobility curves. The curve for pectic substance is characteristic of a highly acidic substance whereas that of depectinized cotton shows a low order of acidity. The curve for dewaxed cotton appears to be a composite of the curves for cellulose and pectic substance.

The purified cellulose exhibits a reversal of charge below pH 2.5, and accordingly is isoelectric at that pH. It is shown that the

* Research associates at the National Bureau of Standards, representing the Textile Foundation, Inc.

reversal of charge has not resulted from irreversible changes produced in the fiber during immersion in the dilute solutions of acid used in the present investigation.

Introduction

RECENT studies on cotton have indicated that the pectic substance occurs principally on the surface of the fiber as part of the primary cell wall.[1, 2, 3] Although this substance is present to the extent of only approximately one percent, it nevertheless accounts for about 85 percent of the acidic groups in mature fibers. The remainder of the acidic groups, about 15 percent, are presumably associated with the cellulose itself.[4] The highly acidic nature and the location of the pectic substance in the naturally-occurring fibers, would be expected to influence greatly a number of the properties of the fiber, especially those dependent on surface characteristics. These surface characteristics are of considerable importance in a number of industrial processes, as for example, the scouring, dyeing and finishing of textile materials.

The electrophoretic technique has been shown in this laboratory to be a useful tool for characterizing and distinguishing surfaces of different textile fibers or of fibers of which the surfaces have been altered by different chemical treatments.[5, 6] Since it would be expected that the surface of a cotton fiber might also be appreciably changed by treatments which are known to remove pectic substance, it appeared that electrophoretic measurements would be of considerable aid in evaluating such changes.

Materials and Methods

1. Materials

Raw cotton was extracted with alcohol at room temperature for 24 hours, and then with ether for 24 hours. This will henceforth be described as *dewaxed cotton.*

A portion of the dewaxed material was further purified by extraction for 2, 4, 8 or 16 hours with a boiling 1-percent solution of sodium hydroxide, according to the method recommended for the preparation of standard cellulose. The procedure was essentially the same as that described by Corey and Gray,[7] except that the apparatus of Worner and Mease was employed.[8] It has been shown by Whistler, Martin and Harris that this treatment removes all measurable amounts of pectic substance from cotton.[9] Samples purified in this way will be termed *depectinized cotton.*

All of the above samples were reduced to a convenient particle size by grinding them in a laboratory Wiley mill until they passed through a 60-mesh screen. The powder was suspended in water, the larger particles were allowed to settle, and the particles (1 to 5 microns) remaining in the supernatant liquid were used for the measurements.

Pectic substance was obtained by treating dewaxed cotton with a solution of sodium hexametaphosphate, shown elsewhere[10] to separate readily the pectic substance from cotton. The procedure was as follows: 100 g of dewaxed cotton was soaked at room temperature for 7 hours in one liter of a 0.5-percent solution of sodium hexametaphosphate at pH 7.9. The liquid was pressed out, and the cotton was soaked overnight in an additional 1-liter

portion of the same solution. The combined solutions were dialyzed against running distilled water for 2 days. Hydrochloric acid and potassium chloride were added to portions of the solution until the final ionic strength was 0.02 *M* at pH values from 1.7 to 4.1. Microscopically visible particles suitable for mobility measurements were found to be suspended in the acidified solutions.

2. Methods

The electrophoretic technique was the same as that used in earlier studies on silk [5] and wool [6] fibers. An Abramson microelectrophoresis cell was used for the measurement of electric mobility.[11] The methods suggested by Moyer were followed in detail.[12] When the mobilities were very low, which was the case for all of the depectinized samples, the velocities of the particles were measured in successive layers from the top to the bottom of the cell, and the mobility was evaluated by graphical integration of the curve obtained by plotting velocity against depth.[11]

Preliminary measurements showed that throughout the range of pH investigated, there was no appreciable change of the mobility of the pectic substance or of the dewaxed or depectinized cotton when suspensions were allowed to stand from 15 minutes to 24 hours before mobility measurements were made.

The pH values of the suspensions were measured with a McInnes and Belcher-type glass electrode and a vacuum-tube potentiometer, using a cathode-ray tube as null indicator The pH values were referred to potassium acid phthalate, 0.05 *M*, to which was assigned a pH value of 4.01.[13]

Experiments and Discussion

Curve 5, figure 1, shows the pH-mobility curve for pectic substance. The curve is typical of that of a highly acidic substance, since the particles exhibit a large negative charge even at pH 1.7. This is consistent with the results of an earlier investigation, which showed that the entire uronic acid-carboxyl content of the pectic substance was present in the forms of titratable carboxyl groups.[4] The pH-mobility curve for dewaxed cotton (curve 4) is similar in shape to that for the pectic substance, but the material is shown by the shift in the curve along the axis of ordinates to be less acidic than the pectic substance. If the particles of dewaxed cotton were completely coated with pectic substance, a curve identical with curve 5 would have been obtained. The results suggest that cutting the fibers exposes new surfaces which are presumably cellulosic, and since these are much less acidic than the pectic substance itself, the number of acidic groups per unit surface has accordingly been decreased. It would appear then that curve 4 is a composite of the curves for the highly acidic pectic substance and the much less acidic cellulose.

The pH-mobility curve of a sample of depectinized cotton, prepared by treating dewaxed cotton for 2 hours with a boiling 1-percent solution of alkali, is shown in curve 3. Its position relative to the curve for dewaxed cotton indicates the removal of an acidic component. Slight further shifts in the pH-mobility curve were caused by 4 hours (curve 2) and 8 hours (curve 1) of extraction with the alkali, but these last effects are much smaller. A sample treated for 16 hours gave no further change in the pH-mobility curve (curve 1).

The small shifts in the positions of the pH-mobility curves for samples of cotton treated for 4 and for 8 hours were somewhat surprising, especially since earlier determinations of uronic acid[9] as well as titration studies[11] had indicated that essentially all of the pectic substance was removed from the fiber during the 2-hour treatment with alkali. It must be pointed out, however, that the electrophoretic measurements are much more sensitive to

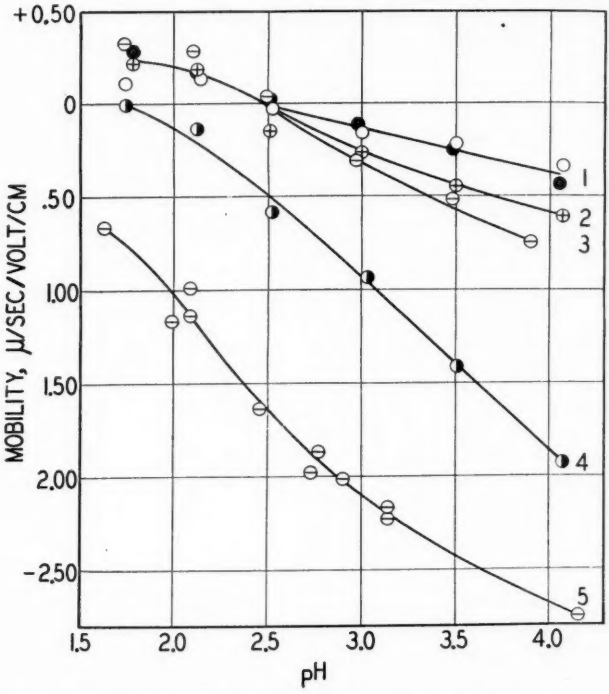

Fig. 1. A comparison of the pH-mobility curves for dewaxed cotton, depectinized cotton, and pectic substance from cotton.
Curve 5 represents the mobility of the pectic substance. Curve 4 is that for dewaxed cotton. Curve 3 is that for cotton treated with boiling 1 percent NaOH for 2 hours. Curve 2 is for cotton similarly treated for 4 hours. Curve 1 is for cotton treated for 8 (open circles) and for 16 hours (filled circles).

small changes than either of the above techniques and therefore the possibility that removal of the last traces of pectic substance during treatment with alkali for 2 hours is not complete, cannot be ruled out. If the data are interpreted in this light, then they must also be taken to indicate that the samples treated for 8 and for 16 hours are essentially free of pectic substance.

Two alternative explanations for these shifts may be advanced. First, the continued treatment with alkali may remove a small amount of surface material which contains no carboxyl groups but which is more electronegative than the cellulose itself. Second, the continued treatment with alkali may alter the physical structure of the fiber, with a resultant change in the mobility curve. Numerous instances exist in which a physical change, such as alteration of the degree of orientation, has been shown to change the electrokinetic properties of substances. Kanamaru, for example, has observed that the zeta potentials are different for rayons spun of the same material, but of varying degrees of orientation,[15] and a similar observation has been made on nylon by Sookne and Harris.[14] Harrison found a large decrease in the (negative) zeta potential of cotton after mercerization,[16] and since the small changes observed in the present investigation are in the same direction, they could possibly be caused by alteration of the physical character of the fiber surface.

It will be noted that the depectinized samples of cotton exhibit reversal of charge below about pH 2.5 and accordingly are isoelectric at that pH. However, it has been reported[17] that cellulose has no true isoelectric point and that reversal of the charge in the more acid solutions resulted from hydrolysis at the surface of the fiber. Although these conclusions arose from investigations on wood cellulose, it nevertheless appeared advisable to determine whether any irreversible effects had ben produced under the conditions of the present studies. For this purpose, the following experiments were performed. 1.5-g samples of ground, depectinized (8 hour) cotton were soaked in 400-ml portions of hydrochloric acid—potassium chloride solutions (0.02 *M* ionic strength) having pH values of 1.7, 2.5, and 3.3. These solutions were identical with those used in obtaining the data shown in fig. 1. After 1 hour, the samples were filtered off on a sintered glass funnel and thoroughly washed with running distilled water. Water suspensions of each of the three samples as well as of a sample of the untreated, depectinized cotton were then prepared and sufficient acetic acid and sodium acetate added to bring the pH value of each solution to 5.6 and the ionic strength to 0.005 *M*. The samples were allowed to remain in contact with the buffer solutions for 24 hours, after which the mobilities of the particles were measured. No significant differences between the acid-treated and untreated samples were found and therefore it was concluded that no irreversible changes in the surface potential of cotton were produced by the dilute solutions of acid employed in the present work.

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One Year Textile Course for College Graduates

The Textile Foundation of Washington, D. C., announced April 18, 1941, the availability of a pamphlet entitled, "A One Year Textile Course for College Graduates."

Authored by Thomas R. Taylor, former Assistant Director of the Bureau of Foreign and Domestic Commerce and teacher in business schools and universities, the 26-page pamphlet, based on a nation-wide survey, emphasizes the need for inauguration of a special one-year course for college graduates in textile technology and economics.

"Industry leaders are almost unanimous in the conviction that more college men should be fed into the industry," Mr. Taylor says, and points out that they feel, "The one-year course may be an ideal method of recruiting."

It is indicated that in the marketing or manufacturing of cotton textiles alone, several hundred such college graduates annually could be used to good advantage.

A survey of the questionnaires sent to college graduates now employed in the industry shows that 77 per cent would have taken such a course had it been offered at the time of their graduation. These men report lack of training courses in textile mills and houses, and, therefore, an additional handicap imposed on the liberal arts graduate who enters the industry.

The survey also reveals that deans of textile schools view the one-year course as a stimulating educational venture and that other educators favor the plan on both theoretical and practical grounds, in that it keeps pace with modern educational methods and would serve to develop managerial talent.

The industry's trade associations and trade journals are enthusiastic, since the effort would tend to raise the standard of executive raw material within the industry.

In his report, Mr. Taylor draws the following conclusions:

1. There is sufficient evidence of the need for establishing a one-year course to justify one or more textile schools in adding it to their curricula. The demand arises particularly from executives within the industry who are anxious to increase the ability of the younger personnel to contribute to the pressing managerial problems of the times.

2. In view of the nature of the demand, it would seem logical that the course should give primary emphasis to managerial work rather than technical education.

3. To be worked out successfully, the course must be offered at some central location and must be well planned in order to justify the expenditure of a full post-graduate year. The students, teachers and outside lecturers must be carefully chosen, and the course must be creative and stimulating throughout in order to attract top-notch men. Especial effort should be made to place graduates in the industry and to follow their work from year to year.

The pamphlet may be obtained without cost by addressing a request to The Textile Foundation, Industrial Building, National Bureau of Standards, Van Ness St. and Connecticut Ave., N.W., Washington, D. C.

The Textile Foundation was organized for scientific and economic research for the benefit and development of the textile industry and its allied branches, including raw materials. The Directors of the Foundation are: Franklin W. Hobbs of Boston, Chairman, Frank D. Cheney, Manchester, Conn., Treasurer, Donald Comer, Birmingham, Ala., the Secretary of Agriculture, Claude R. Wickard, the Secretary of Commerce, Jesse H. Jones, and the Secretary of The Textile Foundation, Edward T. Pickard.

Fabric Properties of Blends of New and Reprocessed Wool*

By BARBARA BAILEY †

Abstract

Physical and chemical effects of blending new and reprocessed wool have been investigated before and after varying numbers of commercial dry cleanings and pressings.

Differences in fundamental fabric properties were found for the four blends of wool used, although identical manufacturing and finishing processes were employed.

Ash content tended to increase with dry cleaning, sulfur was not appreciably affected, and the nitrogen content showed a marked increase between the fifteenth and thirtieth dry cleanings.

Applications of statistical methods to the tests of strength and elongation showed in general that blending the sources of new and reprocessed wool used in this study resulted in decreases in fabric strength and elongation as the percentages of reprocessed wool were increased, and these differences persisted through forty-five dry cleanings and pressings. The effects of dry cleaning and pressing were mixed and nominal in magnitude.

Introduction

THE President of the United States recently approved a bill requiring that commencing July 14, 1941 fabrics containing wool must be labelled with the percentages of new, reprocessed, and re-used wool present; the law to be administered by the Federal Trade Commission. The effects of this legislation will be felt by wool producers, manufacturers, retailers, and consumers. Because of the interest which the state of South Dakota has in wool production and quality, a study of the physical and chemical properties of flannel fabrics manufactured from mixtures of virgin wool and reprocessed wool was initiated at the South Dakota Agricultural Experiment Station in 1938.

Publications of wool fabric investigations in which the exact identity of the wool present is known are few in number. Studies which have been reported are the results of investigations by Leeds University,[1] Barker,[2] and the Bureaus of Animal Industry and Home Economics of the United States Department of Agriculture cooperating.[3, 4, 5]

In the present study wool from Rambouillet sheep was used as the source of virgin wool. The staff of the Lowell Textile Institute, where the fabrics were manufactured, purchased the reprocessed wool on the open market. This wool was from pastel sweater clippings. The following

* Published with the permission of the Director of the South Dakota Agricultural Experiment Station as paper number 148.

† Research Assistant in Home Economics.

blends were used in manufacturing the fabrics: 100 per cent virgin; 75 per cent virgin, 25 per cent reprocessed; 50 per cent virgin, 50 per cent reprocessed; and 25 per cent virgin, 75 per cent reprocessed wools. Since considerable waste resulted from the various stages of manufacture of fiber into fabric, it is recognized that these percentages may not have been maintained throughout. For convenience in the discussion of the results, the fabrics will be referred to by the designations given above. A 2×2 even twill weave was used in the construction of the fabrics. Following weaving, each fabric was given a simple finishing process consisting of washing and pressing.

Methods

Physical and chemical tests were applied to each of the fabrics as they were received from the manufacturer and after commercial dry cleaning and pressing for 15, 30, and 45 times. In conducting the physical tests upon the yarns and fabrics an air-conditioned laboratory maintained at ASTM [6] standards (65 per cent $\pm$ 2 per cent relative humidity at 70 ± 2 degrees F.) was used throughout, and all samples were conditioned for a minimum of six hours before testing.

The fiber used in the fabrics was graded by measurements of 1000 cross-sections of fiber magnified to 500 diameters. The method used has been described in detail by Bailey.[7] Fiber length and crimp were determined by measurement of individual fibers.

The Suter twist tester with spinning twist attachment was used in determining yarn twist for each sample, and yarn strength and elongation were measured on the Scott single strand tester, 50 yarns being used in each case. Standard ASTM [6] procedures were used throughout in testing weight per square yard, number of yarns per inch, thickness, shrinkage, strip and grab tensile strength and elongation, ball bursting strength, and tearing strength. The Wyzenbeek precision wear-test meter was used in determining the effect of abrasion upon strength and elongation. Ten samples were used in all fabric measurements of strength and elongation.

Analyses of total ash, sulfur by the Parr bomb, and total nitrogen were made on samples of fiber and the fabrics at various stages of treatment.

Experimental Results

Fiber

Upon measurement of the physical characteristics of the sources of fiber it was found that the new fiber averaged 40 per cent longer than the reprocessed fiber, and that the average number of crimps per inch was 10 per cent greater in the instance of the new wool. The mean contour ratio was 1: 1.25 in the case of both the new and reprocessed wools, while the new wool was fine and the reprocessed wool graded ½ blood. In all instances of physical measurements the reprocessed wool was more variable than the new wool. The ash content of the new wool was twice that of the reprocessed wool, the total nitrogen slightly greater, and the sulfur slightly lower.

Fabric

Although identical processes were used throughout in the preparation of the four fabrics, materials with the same fundamental fabric character-

istics did not result. Thus, while the thickness and twist were approximately the same in the four materials, the average weight per square yard decreased as the percentage of reprocessed wool increased. While it is recognized that there were inherent differences in the four fabrics, the data obtained upon analysis are discussed in terms of the actual results found, the constant factors being identical manufacture and dry cleaning processes rather than identity in finished fabrics.

Since fabric weight decreased progressively with increasing percentages of reprocessed wool, it must be concluded that the nature of the fiber resulted in more carding and spinning waste as the percentage of reprocessed wool was increased. In this same connection a comparison of the average diameter of the fiber present in the finished fabrics with the sources of fiber is of interest. The results of this study are shown in table 1. From these data it is apparent that in the case of the 100 per cent virgin fabric, the

TABLE 1. COMPARISONS OF THE DIAMETER BETWEEN THE SOURCES OF FIBER AND THE FABRICS MANUFACTURED FROM THEM.

Source of Wool	Diameter Mean * microns	Diameter St'd Deviation microns
Virgin fiber	21.16	5.03
Reprocessed fiber	25.72	7.22
100% virgin fabric	21.30	5.16
75% virgin fabric	21.71	5.52
50% virgin fabric	21.77	5.73
25% virgin fabric	22.04	6.56

* 1000 measurements.

manufacturing processes did not affect either the diameter or distribution as measured by the standard deviation (s). It would be anticipated that the average diameter of the wool present in the fabrics containing reprocessed wool would increase, approaching that of the reprocessed fiber, as the percentage of the latter became higher. However, as is shown in table 1, this was not the case. The diameter did increase slightly but not to the extent that would be anticipated. Thus during the manufacturing processes the coarser fiber must have been eliminated to a certain extent.

Effects of Fabric Treatments

Chemical determinations

Analyses of the four fabrics as woven and after dry cleaning and pressing 15, 30, and 45 times, with few exceptions, showed a tendency for an increase in ash content with increasing numbers of dry cleanings. In all four fabrics there was a marked increase in nitrogen between the fifteenth and thirtieth dry cleanings which could not be accounted for on the basis of any of the other physical or chemical experimental results. There were no well defined trends in the sulfur content of the fabrics as a consequence of blending or treatment. In some instances a fabric had a higher sulfur content as a result of one stage of treatments, while in other fabrics this treatment may have caused a lowering of the sulfur content.

Physical determinations

In the discussion of the effects of abrasion and dry cleaning and pressing, statistical methods have been applied in the comparisons between the four fabrics in the various stages of treatment. Applications of Student's "t" test for significance of difference between means was applied in comparisons of strength and elongation before and after mechanical abrasion for 1000 double rubs. The strength in the warp and filling directions was found to decrease following abrasion. Interpretations of the effects of blend and fabric treatment are based on calculations of analyses of variance. Because homogeneity of errors is assumed in calculations of

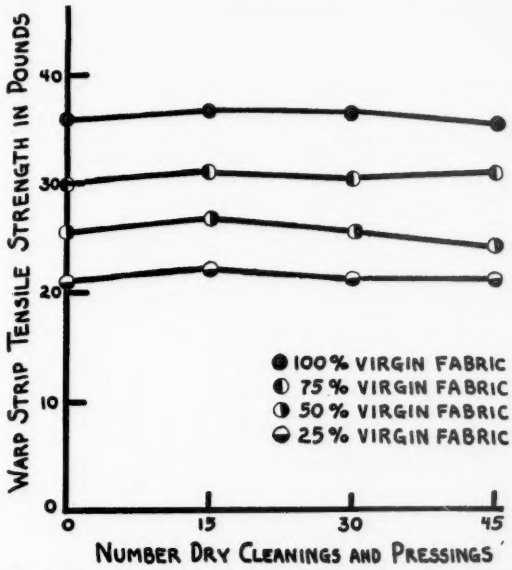

Fig. 1.—Warp Tensile Strength of Fabrics Before and After Varying Number of Dry Cleanings and Pressings.

analyses of variance, the chi square test was used to determine whether the variability of the strength and elongation measurements for the fabrics subjected to the various numbers of dry cleanings and pressings were homogeneous (Snedecor).[5] Homogeneity of errors was found in all instances. In calculations of the analyses of variance the degrees of freedom may be keyed out as follows:

Variation Due to:	Degrees of Freedom
Blend	3
Treatment	3
Blend × treatment	144
Total	159

Interpretation of the results was made in two ways depending upon the information desired. If the residual factor is used as error, the interpretation would apply to the specific fabrics and treatments involved in this study. However, it is of interest to expand the interpretation to indicate the general effects of mixing new and reprocessed wool and the effects of dry cleaning and pressing processes. As has been suggested by Immer,[9] the interaction is the proper error in this case.

In the discussion which follows the results of the analyses of variance determinations on the warp strip strength of the fabrics will be considered in detail, since the data shown graphically in figure 1 indicate the typical response found for the fabrics in all tests of strength to which they were subjected. A summary of the results of other measurements of strength and elongation will be presented.

In table 2 are shown the F values for the warp strength determinations using both the residual and interaction as error, the actual results which are the basis of these calculations having been indicated in figure 1 above.

TABLE 2. F VALUES BY MEANS OF THE ANALYSES OF VARIANCE FOR THE WARP STRIP STRENGTH DETERMINATIONS USING RESIDUAL AND INTERACTION AS ERROR.

Variation Due to :	Degrees of Freedom	F Values	
		Residual as Error	Interaction as Error
Blend	3	1857.98 *	1074.97 *
Treatment	3	10.90 *	6.30 †
Blend × treatment	9	1.75	——

* Highly significant.
† Significant.

Considering first the results using the residual factor as error, it may be seen that the four fabrics differed significantly in strength. This would be anticipated by examination of figure 1 in which it was shown that strength decreased regularly as the percentages of reprocessed wool became greater. Table 2 indicates that the three dry cleaning and pressing treatments themselves differed significantly. Thus in the warp strip measurements the strength variance was greater after 15 dry cleanings followed by progressively decreasing variances at 30 and 45 dry cleanings and pressings. The test for the significance of the effects of treatment upon the various blends is computed by dividing the mean square for interaction by the error mean square. As is shown in Table 2 the effects of treatment upon the warp strip strength of the four fabrics were similar, and value of 1.75 as computed not being statistically significant.

When the results using the residual factor as error were studied for all the measurements of strength and elongation, it was concluded that the four fabrics were significantly different in measurements of strength and elongation; the treatments to which they were subjected were significantly different; and in some instances the four fabrics did not react similarly to treatment as registered in terms of strength and elongation. The actual measurements showed that the fabrics decreased in strength in progressing from the 100 per cent virgin fabric to the 25 per cent virgin fabric when similar manufacturing processes were employed. Elongation likewise decreased as the percentage of reprocessed fiber was increased. Dry clean-

ing and pressing increased strength in some instances and lowered it in others.

When the interaction of blend × treatment is used as error in interpreting the results to indicate the general effects of blending new and reprocessed wool, it is recognized that the inclusion of a larger number of blends and treatments would be desirable, and that the results are applicable only to blends in which the fiber properties are similar to those found in this study. Thus the combination of all grades of new and reprocessed fiber could not necessarily be used in producing fabrics having the properties found in this study.

The F values in Table 2 indicate that appreciably varying the blend of new and reprocessed fibers in flannel fabrics yielded fabrics which differed significantly in the warp strip measurements. This table likewise showed that the treatment effect was significant.

If all of the measurements of strength and elongation as a function of blending and treatment are summarized, it appears that blending new and reprocessed wool of the types employed in the present study in varying proportions and subjecting them to the same manufacturing processes resulted in fabrics of different strength and elongation, and these differences persisted throughout subsequent dry cleaning and pressing processes. Dry cleaning and pressing the fabrics affected strength and elongation significantly in some instances and non-significantly in others, regardless of the blend.

Acknowledgment

The author wishes to express her gratitude to Dr. S. P. Swenson, formerly Associate Professor of Agronomy at South Dakota State College; and to Dr. F. R. Immer, Professor of Agronomy and Plant Genetics at the University of Minnesota for assistance in the statistical interpretation of the data; and to the Division of Home Economics at the University of Minnesota for the use of their air-conditioned laboratory and equipment.

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Summer Session Course in Textile Testing at M. I. T.

A special summer course in Principles of Textile Analysis is again announced by the Massachusetts Institute of Technology. The comprehensive program will be under the personal direction of Professor Edward R. Schwarz, in charge of the Textile Division, and will continue for six weeks beginning July 28th.

Laboratory exercises as well as lectures and demonstrations will cover the complete microscopic analysis of textile materials; physical testing, including heat transmission, permeability to air, abrasion, flexibility, drape, water resistance, fastness to light and washing, resilience, interpretation of data, and application of statistical methods to textile testing. So far as possible the material will be presented in a manner to be of interest and value to the laboratory technician, to the manufacturer who must increasingly interpret technical information developed by research for the benefit of his organization, to the teacher of this and allied subjects, and to the student who seeks a short orientation course in textile research and testing.

Opportunity will be afforded to study the new electron microscope, stroboscopic photography, stereoscopic photomicrography, and the spectrophotometric color analyzer. New equipment for refractive index measurement, single filament testing, resilience, heat transmission, permeability, photo-electric twist measurement for single yarns, fluorescent lighting for photomicrography, cotton maturity, wool quality, and rapid sectioning are also available.

Previous courses have been very successful and the present popularity of the work in textile technology is evidenced by the fact that the Engineering Defense Course in Textile Testing was oversubscribed by four to one and is now being repeated for a capacity group. Registration material for the summer session course and information concerning the work are available from the Summer Session Office, M. I. T., Cambridge, Massachusetts, upon request and applications to the extent of the laboratory capacity will be accepted in the order of receipt.

The Disposal of Textile Wastes with Domestic Sewage*

By ROBERT K. HORTON † and HERMAN G. BAITY ‡

A Textile Foundation Publication

Abstract

Disposal of textile wastes with domestic sewage appears logical since it reduces the capital outlay for plant facilities, places all treatment under constant and skilled supervision, and eliminates many chances of neglect and mismanagement by mill labor. Of the many problems arising from combined treatment the most important is the character of sewage reaching the disposal plant. Equalization and regulation of discharge of industrial wastes are necessary to prevent rapid change in environmental conditions for the bacteria and other organisms carrying on purification processes. Reduction of waste volume and recovery of by-products should be employed wherever practical. Preliminary treatment, including neutralization, chemical precipitation, and aeration is sometimes necessary to lessen the load applied to biological processes. The activated sludge process and biological filters employing recirculation of the effluent can be used successfully to treat textile wastes-domestic sewage mixtures. The activated sludge process removes color better, but it is more easily upset by variations in the character of the waste. In general, digester capacity will have to be increased when treating textile wastes with domestic sewage.

The successful treatment of textile wastes in conjunction with domestic sewage calls upon the operator for the highest type of service. By means of adequate control and adjustment of the various processes excellent results are obtainable.

Introduction

THE treatment of industrial wastes along with domestic sewage often creates numerous and difficult problems at the sewage disposal plant. However, these problems can be solved economically and satisfactorily. Combined treatment of sewage and textile wastes is the most logical method because sewerage and sewage treatment are normally functions of a city. An industry located within a city should be able to use municipal facilities for waste disposal. However, a city can not be expected to treat industrial

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wastes which impose unwarranted penalties upon the public at large. The logical solution lies in the allocation of treatment costs to industry and city in a ratio proportional to the load each places on the treatment process, thus making waste disposal facilities available to all on an equitable basis. From an economical standpoint, the treatment of combined wastes appears logical because it avoids the necessity for a separate treatment plant at every mill in an industrial area, and by substituting one treatment plant under constant and skilled supervision eliminates many chances of neglect and mismanagement which might be present in small, intermittently operated plants.

One important problem encountered in the disposal of textile wastes is the corrosion of treatment plant structures and other detrimental effects to sewerage systems caused by certain wastes, but this problem will not be discussed here. The primary aim of this paper is to consider the effects that textile wastes have on the common processes used for treating domestic sewage. Attention is given also to those conditions which must be controlled and regulated either at the source of the wastes or at the disposal plant in order that satisfactory treatment of combined wastes will be possible.

Since 1932 the Textile Foundation, in conjunction with the University of North Carolina, has sponsored a research program for the development of fundamental information on the disposal of textile wastes. The purpose of this program has not been to solve any particular problem of textile waste treatment, because every problem is different. Rather, the aim has been to develop information, basic in nature, which can be generally applied. An experimental station consisting of a series of pilot plants and a laboratory was constructed at the Proximity Print Works in Greensboro, North Carolina. The research work carried on at this station has included study of the customary sewage and waste treatment processes, and investigation of other problems such as the recovery and reuse of certain wastes. Much of the information obtained from this work has already been published in a number of articles, some of which are cited in the bibliography of this paper. Other articles are in the process of preparation and will be published in the near future. The data presented in this paper are based, for the most part, on results that have been obtained at this experimental station.

Equalization and Regulation of Discharge

Of the many problems encountered in the treatment of textile wastes with domestic sewage, the most important and most difficult to control is the character of waste which comes to the treatment plant. Usually, the greatest damage upon treatment processes results from the irregular discharge in large volumes and the wide variation in character of textile wastes. Although the bacteria and other organisms in a sewage plant have considerable ability to adjust themselves to adverse conditions, they can not adapt themselves to a rapidly changing environment. Equalization or averaging of the characteristics of various wastes is therefore necessary if the wastes are to be purified by either chemical or biological means. There are several ways in which equalization may be accomplished. The most common method is the provision for equalization tanks and discharge

devices at each mill. A second method is to bring all textile wastes to the purification plant in a separate sewerage system and equalize them at the plant, but often the cost of additional sewer lines is prohibitive. Whenever textile mills are concentrated in a limited area, as they often are, their wastes might be collected and equalized in tanks located in the industrial district. The method of equalization which will be most economical for any particular situation will, of course, depend upon local conditions. Not only is it necessary to equalize the character of the wastes, but also it is necessary to maintain a fairly constant ratio between the volumes of industrial and domestic wastes so that the mixture being treated in the plant will be relatively uniform. This necessitates the use of equipment which will regulate the discharge of the equalized waste in proportion to the sewage flow.

Recovery and Reduction

Equalization and regulation of discharge are always necessary whenever textile wastes are to be treated by domestic sewage processes. When the volume of textile waste is small in proportion to the volume of domestic waste, equalization and regulation may provide sufficient protection to treatment processes. However, generally they do not provide sufficient protection, either because the volume of industrial wastes is excessively large or because the wastes are particularly strong or toxic. In these cases it is necessary to adopt additional methods for controlling the waste before it reaches the treatment plant. The methods for additional control are: recovery, reduction, and preliminary treatment.

Recovery.—Benefits may be derived from the recovery of by-products in two ways: the value of the by-products, and the reduction of pollutional material carried in an industrial waste. Even though recovery processes do not always result in a direct profit, due consideration should be given to the effect of these processes on the lowering of subsequent waste treatment costs.

A considerable amount of work has been done at the Textile Foundation Experiment Station in Greensboro on the recovery of dyes and on the recovery of chemical coagulants used for precipitating textile wastes. Sulfur, vat, and direct dye wastes have received the most attention. The coagulants which have been used for most of the work are the iron salts (ferric chloride, ferric sulfate, and copperas), alum, and lime. The procedure has been to chemically precipitate the strong wastes and then by acid digestion of the sludge to remove the coagulant from the dye. The coagulant has then been reused to precipitate more waste. The results of this work are promising and will be published soon. Recovery of sulfur dyes has given the best results; in some cases the recovered dye has given a color as high as 90% of that given by an equal weight of original dye. Vat dyes have also been recovered successfully, but the results obtained with direct dyes have not been satisfactory. The amount of coagulant recovered has been as high as 95% but averages around 60% to 70%. Recovery is not necessarily limited to dyes. There are many instances where it might show promise, such as the recovery of weighting salts, oils, caustic soda from mercerizing liquors, kier liquor, bleach solutions, accessory chemicals, and many others.[1]

Reduction.—Another method of lessening the load upon disposal plants and in turn the cost of waste treatment is to reduce the volume of industrial wastes. This may be accomplished by keeping the amount of wash waters discharged at a minimum, or by making certain changes in the manufacturing processes. In some cases it might be possible to use the waste liquor from one operation for making up the bath in another, with the result that one waste bath will be eliminated. Also, the reuse of strong chemical solutions to greater exhaustion reduces the pollutional characteristics of the waste, a... onsequently the amount of treatment which will be required. This method of reducing industrial wastes is of particular importance to manufacturers, and there are many cases where it might be employed. One practical example is furnished by a mill which reused a strong caustic boil-out liquor for subsequent kiering operations. In addition to lowering waste treatment costs by reducing the volume and strength of its waste, the mill has also realized considerable savings in the amount of caustic it uses.

Preliminary Treatment

Even when the above mentioned methods for controlling the flow of textile wastes are employed, preliminary treatment is often necessary before the stronger wastes can be treated with domestic sewage. The types of preliminary treatment most commonly used are neutralization, chemical precipitation, and preliminary aeration. Since most textile wastes are highly alkaline, if biological processes are to function the pH must be adjusted to within the neutral range. This may be accomplished by the addition of sulfuric acid with equipment which will automatically control the pH.

Chemical Precipitation.—Chemical precipitation is one of the most important methods for the purification of textile wastes; however, it is expensive. There are three classes into which the discharges from textile mills may be divided, namely: 1. very dilute wash waters which may not need treatment, 2. wash waters which can be discharged directly into domestic sewers without placing an undue burden on the municipal treatment plant, and 3. strong wastes which must receive preliminary treatment before purification by a biological process. The cost for preliminary chemical treatment may often be reduced by proper control of these different types. If the strong wastes can be isolated the cost may be less than when all the wastes are composited, since it may be cheaper to treat a small volume of strong waste at high unit cost than to treat a large volume of composite waste at low unit cost.

Studies were made on the chemical precipitation of textile wastes both on a laboratory and pilot-plant scale.[2] A great variety of wastes and most of the common coagulants were investigated. Excellent color removal was obtained with practically all of the wastes, and reductions in B.O.D. of 60 to 85% were obtained. However, because of the high cost of chemical treatment, it appears economical to use other treatment methods whenever they are possible, and to use chemical precipitation only as preliminary treatment when it is necessary to lessen the load applied to biological processes.

Preliminary Aeration.—Certain textile wastes contain strong reducing chemicals which give the waste a large immediate oxygen demand. There-

fore, it is sometimes necessary that the waste receive preliminary aeration, particularly if it is to be treated by the activated sludge process.

Since equalization, regulation of discharge, and preliminary treatment are vital to the satisfactory operation of a plant treating textile wastes along with sewage, the sewage plant operator should be responsible for them even when the facilities are located at the mill.

Activated Sludge Process

Purification of textile wastes by any biological process depends primarily upon the ability of purifying organisms to adapt themselves to new environmental conditions. This power of adaptability can be utilized in treating wastes only if the environment is not changed too rapidly. For any purification process to function it is first necessary that the organisms be acclimatized to the maximum concentration of industrial waste they are capable of handling, or to the concentration it is desired to treat. This can be accomplished by starting the process on plain sewage and gradually building it up by adding increments of textile waste.

The two most important methods for the purification of sewage are the activated sludge process and biological filtration. Both processes when properly controlled appear to be effective for treating textile wastes in conjunction with domestic sewage. One of the most important objections to the activated sludge process is that it is the most sensitive or easily upset of all biological methods of purification. However, when operating properly, the activated sludge process gives excellent purification.

The feasibility of treating textile wastes by the activated sludge process and the optimum operating conditions have been investigated by the Textile Foundation. Practically all of the studies were confined to the treatment of sulfur black dye waste. It is believed that the results obtained are generally applicable to activated sludge plants handling textile wastes, since sulfur black dye is one of the most difficult of all textile wastes to treat. Sulfur black dye waste contains pigment, a sulfur compound, sodium sulfide, salt, a small amount of caustic soda, and other chemicals. It has an intense blue black color, a total alkalinity of 18,000 p.p.m., a B.O.D. of 10,000 p.p.m., a total solids content of about 9% of which 23% is volatile, and a pH of about 11.2. Pilot-plant scale investigations were made on the fundamental factors controlling the process. Four aeration tanks, containing approximately 500, 1500, 2500, and 3500 p.p.m. suspended solids, were operated and the length of aeration period, rate of air supply, and concentration of dye waste were varied. This work is summarized as follows:

One series of runs[3] was made using 9-hour aeration periods, 3.86 cu. ft. of air per gallon of aerating mixture, and different concentrations of dye waste-sewage mixtures. The results of these experiments are shown in Figures 1a, 1b, and 1c. The amount of suspended solids carried in the aeration tanks did not greatly affect B.O.D. and suspended solids removal. However, the color removal was greatest in the tank containing the most suspended solids.

Another series of runs[4] was made using 1% dye waste-sewage mixtures, aeration periods varying from 4 to 9 hours, and air at the rate of 1.67 to 5.75 cu. ft. per gallon of aerating mixture. The results of these experiments

are shown in Figures 2, 3, and 4. Variations in the amount of air supplied had little effect on B.O.D. reduction and color removal, but did have some effect on suspended solids reduction. An aeration period of 6 hours gave better results from the standpoint of B.O.D., color, and suspended solids

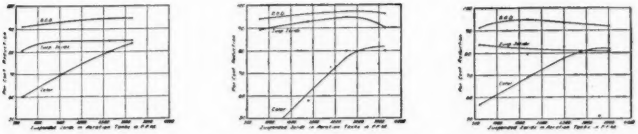

Fig. 1a. Purification Obtained by Treating One-Half Per cent Dye Waste.
Fig. 1b. Purification Obtained by Treating One Per Cent Dye Waste.
Fig. 1c. Purification Obtained by Treating One and One-Half Per Cent Dye Waste.

(Reprinted from *Sewage Works Journal*, Vol. X, No. 2)

removal than a period of four hours. However, 9 hours aeration did not give much better results than six hours. As in the previous series of runs, variations in the amount of suspended solids in the aeration tanks had little effect on the reduction of B.O.D. and removal of suspended solids. Variations in suspended solids concentration did have a decided effect on

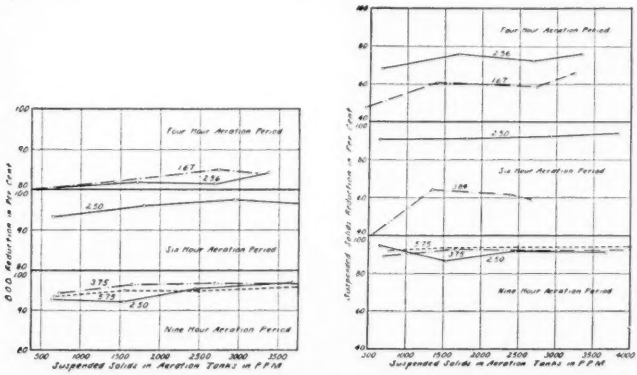

Fig. 2. Reduction in B.O.D. Obtained by Treating One Per Cent Dye Waste. Numbers on Curves Indicate Volume of Air Supplied in Cu. Ft. per Gal. of Aerating Mixture.

Fig. 3. Reduction in Suspended Solids Obtained by Treating One Per Cent Dye Waste. Numbers on Curves Indicate Volume of Air Supplied in Cu. Ft. per Gal. of Aerating Mixture.

(Reprinted from *Sewage Works Journal*, Vol. X, No. 5)

color removal; the purification was almost directly proportional to the amount of suspended solids up to a concentration of 2500 to 3000 p.p.m. but was not appreciably improved by an increase in solids.

Under all conditions of operation the tank containing the largest amount of suspended solids was best able to withstand sudden changes in

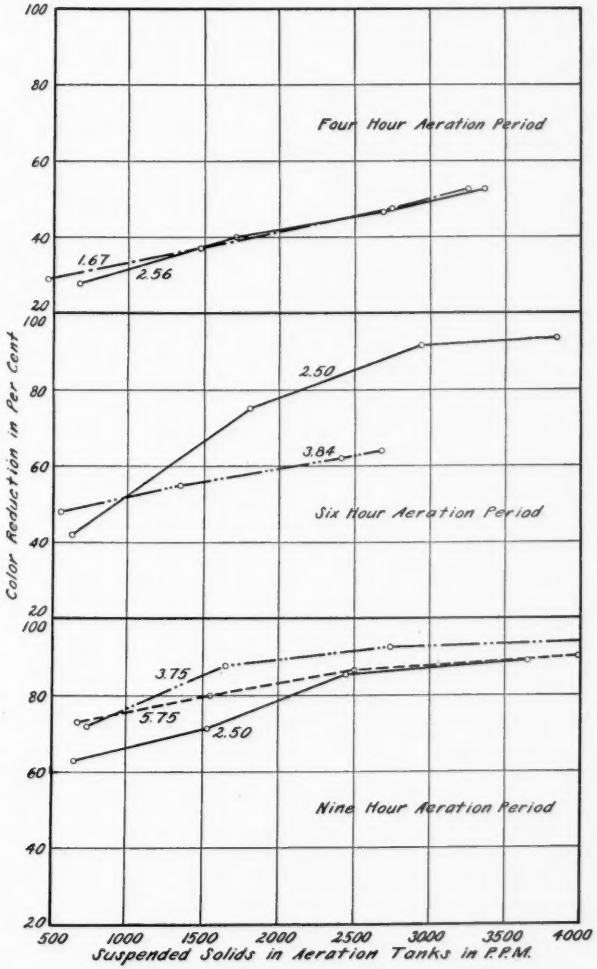

Fig. 4. Reduction in Color Obtained by Treating One Per Cent Dye Waste. Numbers on Curves Indicate Volume of Air Supplied in Cu. Ft. per Gal. of Aerating Mixture.

(Reprinted from *Sewage Works Journal*, Vol. X, No. 5)

the character of the sewage-dye mixture. It is well to bear in mind, though, that generally the more suspended solids carried in the aeration tank, the more air will be required.

Sulfur black dye once separated from solution appears to be acted upon by organisms, since there was no evidence of an accumulation of dye in any of the tanks.

Throughout these studies, the B.O.D. reduction ran between 80 and 98%, suspended solids reduction between 50 and 95 per cent, and color reduction between 30 and 98%. With proper control it was possible to obtain a sparkling clear effluent having a B.O.D. less than 15 p.p.m.

A dye-sewage mixture containing as high as 3% of concentrated dye liquor was successfully treated. There was no indication that this was the upper limit. As actually discharged this concentrated liquor is diluted with wash water about 130 times, or it is only about 0.8 per cent of the total discharge. Obviously then, a total mill waste which is within any reasonable ratio to the domestic sewage flow can be treated.

Disposal of Textile Wastes at the Municipal Disposal Plant in Greensboro, N. C.—An outstanding practical example of the disposal of textile wastes with domestic sewage is the treatment plant at Greensboro, N. C. Some of the most important features of this plant are outlined as follows:

The total volume of waste treated is around 5¼ to 5½ m.g.d. Of this 15% to 20% is discharged from textile mills. The textile wastes include large quantities of sulfur dyes, kier liquor, indigo, and various quantities of other wastes such as vats, directs, color shop and miscellaneous wastes. These wastes are collected and equalized in two lagoons located within the industrial area. From the lagoons the equalized waste is discharged into the outfall sewer in proportion to the domestic sewage flow.

The pH of the textile wastes averages about 9; the pH of the waste-sewage mixture is about 7. Sulfuric acid is used to adjust the pH of the combined waste to around 5 to 6. At the present the acid is added at the disposal plant, but equipment has been installed so that within a short while the acid will be added at the equalizing lagoons just as the industrial wastes are discharged into the sewer.

The B.O.D. of the raw sewage without any textile waste runs about 235 p.p.m. The B.O.D. of the combined waste after the addition of acid is about 350 p.p.m.

After the addition of acid the waste-sewage mixture is precipitated with alum. The average dose of alum is about 60 p.p.m., and after 2 or 2½ hours settling the B.O.D. is reduced from 350 to about 160 p.p.m., and the suspended solids from about 170 to about 45 p.p.m.

After this primary treatment the waste is treated by the activated sludge process. The detention time is around 6 hours, the amount of air is about 1.25 cu. ft. per gal., and the amount of suspended solids carried in the aeration tanks is about 2,000 p.p.m. An important feature is the re-aeration of the activated sludge for about 12 hours before returning it to the incoming waste. It appears that air works more efficiently in a denser concentration of floc. Also, prolonged aeration of the return sludge prevents bulking, which occurred for the first month or two of operation before it was inaugurated.

A noteworthy feature of this plant is the digestion of the excess activated sludge separately from the primary sludge. By using separate

digestion it is possible to draw off a thicker sludge from the primary digesting tank and thus effect a saving in sludge conditioning costs.

The final effluent from the Greensboro plant has a B.O.D. of about 15 p.p.m. and a suspended solids content of about 10 p.p.m. The effluent has a slight blue tint caused by a small amount of dye remaining after treatment. However, it is clear and there is very little colloidal or suspended coloring matter present.

Trickling Filters

A second method commonly used for the treatment of domestic sewage by biological means is the use of trickling filters. Recent investigations by Jenks,[5] Eldridge,[6] and others, have shown that biological filtration offers an efficient method for the treatment of strong industrial wastes together with domestic sewage when recirculation of the filter effluent is employed. Bio-filters can be subjected to a great deal of abuse without adverse results, and consequently they are less easily damaged by changes in the characteristics of the waste. Another point of consideration is that recirculating filters are usually capable of treating a stronger waste than is the activated sludge process. Hence, preliminary chemical precipitation is often not necessary when treating a textile waste-sewage mixture on a recirculating filter. However, biological filters do not remove color as satisfactorily as the activated sludge process. It has been suggested that sewage-textile waste mixtures might be economically treated by applying the waste first to the filter, followed by post treatment if necessary to remove the excess color.

In the work done at the Textile Foundation Experiment Station recirculating filtration has proved to be an efficient means for treating textile wastes. An important feature of the method of filtration investigated has been the recirculation of solids together with the waste liquor. It appears that the recirculation of these solids aids purification through increased adsorption. By adding more solids into the recirculating material it might be possible to improve considerably the color removal. The results of this work are now being prepared for publication. Work has been done on the treatment of sulfur, indigo, vat, direct, and other dye wastes, kier liquor, and composite wastes. The most important results are:

Filter operation is greatly affected by the total time of treatment and the initial load as measured by B.O.D.[7] The optimum time for the treatment of one domestic sewage investigated was around 2 or 2½ hours. An increase in load caused by the addition of sulfur black dye waste requires longer treatment. This is demonstrated in Fig. 5, which shows that purification advanced more slowly for dye waste-sewage batches than for sewage batches of the same volume and treated at the same rates. However, in spite of the lag in purification caused by sulfur dye waste, when a 1% dye waste-sewage mixture was treated over 90% B.O.D. removal was obtained in 3 hours (Curve B, Fig. 5).

Greater concentrations of sulfur dye waste cause greater filter loads, and consequently require longer periods of treatment (Fig. 6).

One of the most important factors influencing filter operation is the number of times the waste is recirculated. In the treatment of a domestic sewage, five appeared to be about the optimum number of recirculations.

In the treatment of industrial wastes the optimum will probably be higher.

Maintenance of dissolved oxygen in the recirculating liquor is essential for maximum purification. This is shown in Table I, which presents the results of several groups of runs. Except for the factor of dissolved oxygen, runs in each group were made under as nearly identical conditions as possible.

Color removal is the chief weakness of the filtration process. In one case it was necessary to treat a 1% sulfur dye waste for over 20 hours before obtaining satisfactory removal.

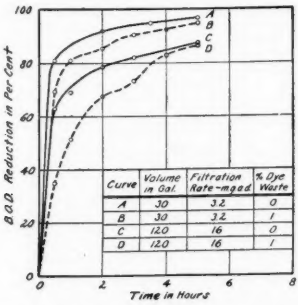
B.O.D. Reduction in Per Cent
Time in Hours
A
B
C
D
Curve | Volume in Gal. | Filtration Rate-mgad | % Dye Waste
A | 30 | 32 | 0
B | 30 | 32 | 1
C | 120 | 16 | 0
D | 120 | 16 | 1

Fig. 5. Comparison in B.O.D. Reduction Between Sewage and 1% Dye Sewage Batches Having the Same Filtration Rates.

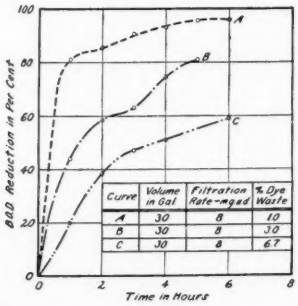

Fig. 6. Effect of Increasing Amounts of Dye Waste on the Treatment of Dye Waste-Sewage Mixtures.

Bio-filters are capable of treating textile wastes having high pH values. For example, when one waste which had a pH above 9.5 was treated, a satisfactory effluent having a pH of around 8.5 was discharged.

Sludge Digestion

Of importance in any disposal process is the problem of sludge digestion. The information available on the effects of textile wastes upon sludge

TABLE I.

EFFECT OF DISSOLVED OXYGEN ON B.O.D. REMOVAL

Group Number	Per Cent B.O.D. Removal	
	D.O. Not Present	D.O. Present
1	61.5	73.6
2	72.0	81.5
3	56.0	81.2
4	54.8	75.0
5	44.8	63.4
6	76.4	85.0

digestion is rather meager. Some work has been done at the Experiment Station in Greensboro,[8] the most important result of which are:

A concentration of sulfur dye waste as low as 0.5% by volume is detrimental to sludge digestion as measured by gas production. A concentration of 6% greatly retards gas production (Fig. 7).

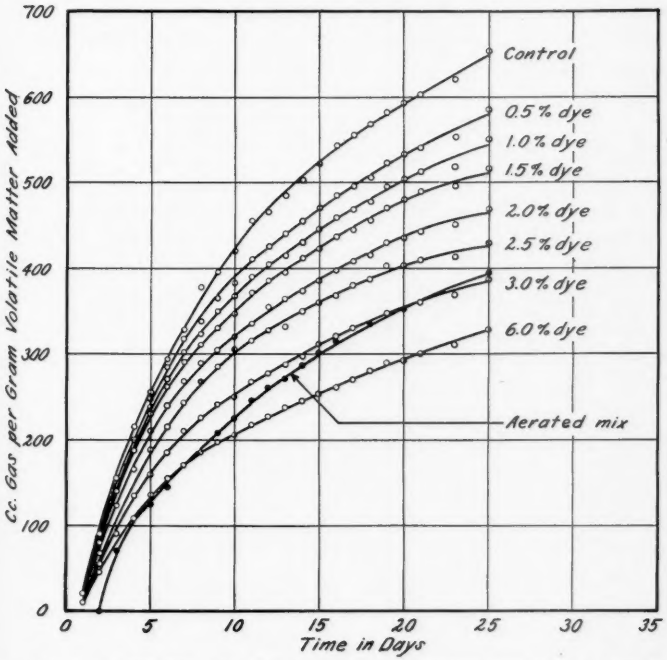

Fig. 7. Cumulative Gas Production from Mixtures Containing Varying Percentages of Dye.

(Reprinted from *Sewage Works Journal*, Vol. XII, No. 3)

Digestion of excess activated sludge from the treatment of a sulfur dye waste-sewage mixture is better than digestion of sewage sludge to which dye waste is added directly. This is shown in Fig. 7, in which the curve marked "aerated mix" is the digestion curve for an excess activated sludge containing approximately 16% sulfur dye. As seen in the Figure, this sludge produced approximately the same amount of gas as a sludge containing only 3% of dye waste which had been added directly.

Sludge digesting organisms, through their ability to adapt themselves to different environment, can be acclimatized to sulfur dye waste. Acclimatization aids in digesting larger quantities of dye waste in a shorter period.

The amount of seed sludge retained in a digestion tank greatly affects gas production. This is shown in Fig. 8. Better gas production was obtained by having a ratio of seed sludge to fresh sludge of 4.75 to 1 (Curve A) rather than a ratio of 2.75 to 1 (Curve B) and 1.19 to 1 (Curve C).

Worth and Baity,[9] in their experiments on the digestion of kier liquor, found that one part of concentrated kier liquor to two parts of seed sludge digested more rapidly than, and produced about four times as much gas as, one part of settled domestic sludge to two parts of the same seed sludge. They stated further that this could be attributed to the decomposition of the kier liquor itself.

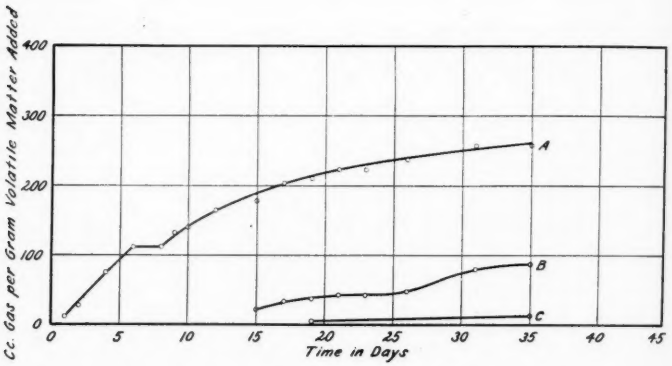

Fig. 8. Cumulative Gas Production of Aerated Mixes Digested with Varying Amounts of Seed Sludge.
(Reprinted from *Sewage Works Journal*, Vol. XII, No. 3)

R. S. Phillips,[10] at Durham, N. C., has done considerable work on the digestion of kier liquor. He has shown that kier liquor is digestible and that the rate of digestion is comparatively rapid. Further he has demonstrated that the optimum amount of seed material to be used with the kier liquor is about 50% of the digester capacity. With this amount of sludge gas production was about four volumes for each volume of kier liquor. The

gas produced was comparable to that from the digestion of sewage sludge; it had an extremely good heating value, and a methane content of around 74%. Greatest reductions in total solids, volatile solids, B.O.D., and oxygen consumed were obtained with a digestion period of about 40 days.

In general, digester capacity will have to be increased when treating textile wastes with domestic sewage. This is one conclusion from the operation of the Greensboro disposal plant.[11]

Acknowledgment

Sincere appreciation is expressed to Professor H. B. Gotaas of the University of North Carolina for his cooperation and helpful criticism, and to Mr. E. H. Moss, Superintendent of the waste disposal plant in Greensboro, N. C., for his valuable information.

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7. R. Porges, H. J. Miles, and H. G. Baity, "Studies on the Treatment of Sewage and Textile Wastes by Recirculating Filtration. I. Domestic Sewage on Batch Basis," *Sewage Works Journal*, Vol. 12, No. 5 (September, 1940).

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11. C. W. Mengel, "Observations on Textile Waste Treatment," *Civil Engineering*, Vol. 10, No. 5 (May, 1940).

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13. H. J. Miles and R. Porges, "Textile Waste Studies in North Carolina," *American Dyestuff Reporter* (December 12, 1938).

14. J. C. Geyer, "The Effect of Industrial Wastes On Sewage Plant Operation," *Sewage Works Journal*, Vol. 9, No. 4 (July, 1937).

15. M. S. Campbell, "The Disposal and Recovery of Textile Wastes," *Textile Research*, Vol. 3, No. 10, and Vol. 4, No. 1 (1933).

16. S. E. Coburn. "Industrial Wastes in Relation to Sewage Treatment," *Sewage Works Journal*, Vol. 4, No. 4 (July, 1932).

17. L. F. Warrick, "The Effects of Industrial Wastes on the Operation of Municipal Sewage Treatment Works," *Sewage Works Journal*, Vol. 3, No. 2 (April, 1931).

18. H. M. Freeburn, "Admission of Industrial Wastes into Sewerage Systems," *Sewage Works Journal*, Vol. 4, No. 1 (January, 1932).

19. S. T. Powell, "Equitable Adjustment of Charges for Treating Trade Wastes. II.," *American City*, Vol. XLVIII, No. 8 (August, 1933).

Changes in Executive Committee and Directorate

The executive committee of the Institute, as named at the Annual Meeting, May 16, 1941, by the Directors, includes in addition to the officers and the Chairman of the Research Council, W. D. Appel, the following: John Bancroft, Jr., Joseph Bancroft & Sons Co.; Earl Constantine, National Association of Hosiery Manufacturers; Alban Eavenson, Eavenson & Levering Co.; Edward R. Schwarz, Massachusetts Institute of Technology; Douglas G. Woolf, editor of *Textile World*.

Directors elected to fill vacancies in the board include: Dr. Smith, Mr. Bancroft, Mr. Callaway, Mr. Constantine; W. M. McLaurine, American Cotton Manufacturers Association; D. H. Powers, Röhm & Haas Co.; Dr. Rose; Albert C. Walker, Bell Telephone Laboratories; and Mr. Woolf.

The directorate of the Textile Foundation includes, in addition to the three industry members named above, the Secretary of Agriculture, Claude R. Wickard, and the Secretary of Commerce, Jesse H. Jones.

Action Taken at Annual Meeting

AFTER MONTHS of study of a special joint committee representing the Textile Foundation and the U. S. Institute for Textile Research, a plan for a broader and more aggressive research program in the textile industry has been developed and put into effect. As announced at the postponed annual meeting of the Institute on May 16, 1941, at the Hotel Commodore, New York, N. Y., the plan calls for a closer association between it and the Foundation. Although remaining completely independent, the two organizations will have a close working arrangement through a common full-time executive. Edward T. Pickard, who has been secretary of the Foundation since its formation in 1930, has been elected executive secretary of the Institute and will devote his full time to the Foundation and the Institute, resigning his position with the U. S. Department of Commerce where for nearly twenty years he has been chief of the Textile Division.

Other officers elected by the Institute at its annual meeting were: Fessenden S. Blanchard, of Pacific Mills, New York, President; Fuller E. Callaway, of Callaway Mills, La Grange, Ga., and Dr. Robert E. Rose, of E. I. du Pont de Nemours & Co., Inc., Wilmington, Del., vice-presidents; Dr. Harold DeWitt Smith, of the A. M. Tenney Associates, New York, Treasurer.

The special committee which developed the plan was composed of Franklin W. Hobbs, Frank D. Cheney, and Donald Comer, Directors of the Foundation, acting for that body, with Mr. Pickard; and Mr. Blanchard, Dr. Rose, Dr. Smith, and Douglas G. Woolf, editor of *Textile World*, acting for the Institute.

The important feature of the new plan is that the Foundation, organized by Congress to promote textile research, will have in the Institute, which is a membership body of technical men and executives in the textile industry, a channel for the transmission of the results of its scientific and economic research to that industry. The Textile Foundation has recognized the desirability of broadening its base of operations as well as the need to inform more fully the textile public of the developments made under its research projects, Mr. Hobbs, chairman, stated in a message to the Institute's meeting. With the new set-up, he added, the Textile Foundation will accelerate and extend its activities, confidently expecting that out of the arrangement with the Institute will be developed a virile organization to carry on textile research when the funds of the Foundation are exhausted, some years hence.

The headquarters of the Textile Foundation will continue in Washington but will be moved to room 225, Industrial Building, National Bureau of Standards. This move will permit of closer administration of the work conducted at the Bureau by fifteen Foundation research fellows. Headquarters office of the Institute will be moved from Boston to New York, exact location to be announced shortly. The headquarters office of the Foundation will serve as the Washington branch of the Institute, and vice versa.

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Abstracts

Committee on Abstracts and Bibliography:
E. R. Schwarz, Chm., Dr. E. J. Saxl, C. H. Clark.

Members of U. S. Institute for Textile Research desiring complete copies of articles abstracted may avail themselves of any or all of the following services by addressing the Secretary's office:

1.—Address of publishers of the periodical abstracted.
2.—Domestic libraries where the abstracted periodicals may be referred to.
3.—Domestic libraries which will furnish photostat copies of the complete article.
4.—Mimeograph or photostat copies of complete articles from abstracted periodicals that are on file in U. S. Institute's library, or in other Boston and Cambridge libraries. These are furnished at cost, and the price plus postage of a photostat negative is seldom more than 50¢ per page of original text.

Address, Secretary's Office: 65 Franklin St., Boston, Mass.

I. Fibers (Synthetic and Natural) and Fiber Analysis

Animal Fibers of Industrial Importance: Origin and Identification. A. B. Wildman. Published by Wool Industries Rsch. Assoc. in conjunction with International Wool Secretariat, 1940, 28 pp. & 33 plates; abs. in *J. T. I.*, Dec. 1940, V. 31, P. A674.

The booklet deals chiefly with the microscopic identification of a preliminary selection of important animal textile fibers, e.g. mohair, alpaca, etc., descriptions of a few potentially useful textile fibers such as the hairs of musk ox and American bison being also included. First, the microscopy of wool fibers is discussed and illustrated by photomicrographs. This is followed by a detailed description of the methods employed in the sampling and preparation of fibers for microscopical examination. The necessity is stressed for practice in the manipulation of fibers from mixtures before quick and accurate decisions upon the nature of a blend can be made. The other fibers are dealt with in separate sections, each with notes on their origin, and, where possible, on the statistics of their production; detailed descriptions are given of diagnostic structural features as aids to identification and all are abundantly illustrated by photographs. (C)

Cotton Fibers: Maturity. N. Ahmad. *Text. Digest*, 1940, V. I, P. 51–8; abs. in *J. T. I.*, Jan. 1941, V. 32, P. A17.

The development of the cotton fiber is briefly discussed and methods of determining fiber maturity are outlined. Factors responsible for the

observed large variation in the maturity count of different cottons, including genetical factors, environment, water supply and insect attack, are briefly considered. It is pointed out that cottons containing high percentages of immature fibers give very neppy yarns and lead to unlevel dyeing. Fiber maturity also has a certain amount of influence on yarn strength. In the relatively long cottons there is a distinct tendency for the cottons possessing higher percentages of mature fibers to yield stronger yarns, but with short-staple cotton the advantage resulting from a high percentage of mature fibers is often lost by the fibers being coarser, as a result of which there are fewer fibers in the cross section of the yarns. (C)

CYSTINE CONTENT OF MERINO WOOL IN RELATION TO ITS PHYSICAL ATTRIBUTES. S. D. Rossouw and V. Bosman. *Onderstepoort J.*, 1939, V. 13, P. 237–42; abs. in *J. T. I.*, Oct. 1940, V. 31, P. A569.

There were no significant correlations between the cystine content and tensile strength, extension, fineness, crimp, scaliness and whiteness of fibers. There was a significant correlation between cystine content and resilience, but its value was not high. It is concluded that the cystine content of merino wool varies less than do the physical characteristics enumerated, that the rôle of cystine in wool production is not important, and that the possibility of improving wool characteristics by means of the cystine content does not appear to be great. (C)

THE FLUIDITY OF SILK SOLUTIONS. PART I, MEASUREMENT; PART II, APPLICATION. Charles Herbert Garrett and Frederick Oliver Howitt. *J. T. I.*, Jan. 1941, V. 32, P. T1.

The method adopted is that of dissolving silk in a reagent containing 8% of ethylenediamine and 6% of cupric hydroxide to give a solution 10% (weight/volume) in silk, calculated as dry weight; this solution is neutralized with an equal volume of acetic acid (to give a solution 5% in silk) and the fluidity is determined. The method of preparing and standardizing the solvent is described. During the early work with this solvent, the viscometer devised by the British Cotton Industry Research Association for work on cellulose was used. It was found advantageous to replace this instrument by a U-tube type and a detailed specification of this viscometer is given. The instrument is readily calibrated by the use of reference standards, e.g. pure phenylethyl alcohol.

Measured by the method described in this paper, the fluidity of a solution of untendered silk is approximately 4 reciprocal poises, whilst for silk chemically tendered to an extent corresponding with almost complete loss of strength, the fluidity is approximately 50. Expressed alternatively in viscosity units, the range is from about 25 to 2 centipoises. As a result of this wide (12-fold) range, a sensitive measure of chemical tendering is obtained that does not require very great accuracy in the measurement of the rate of flow. Examples of the application of the test and typical data afforded are given in Part II of this work. (C)

RAMIE FIBER: IRREGULARITY OF SWELLING IN ALKALI. G. Saito. *J. Soc. Chem. Ind. Japan*, 1940, V. 43, P. 194B; abs. in *J. T. I.*, Dec. 1940, V. 31, P. A674. (C)

II. Yarns and Fabrics

Acid Milling: Practice. *Dyer*, 1940, V. 84, P. 355; abs. in *J. T. I.*, Feb. 1941, V. 32, P. A55.

Acid milling is particularly suitable for heavy plain fabrics, e.g. printers' felts, and for lighter all-wool fabrics (18–24 oz./yard) particularly in hard cross-bred qualities. Compared with alkaline milling, advantages claimed for acid milling are softer hande, less damage to the molecular structure of the wool, saving in time, soap and water, and more even milling with no residual smells or streaks. A disadvantage is the necessity for careful regulation to avoid tendering. Practical working details are given of the process, a preliminary double scour being suggested. With heavy milling, a small amount of water should be added, as evenly as possible, to replace that lost by heat during the process. Figures are given showing the improved warp and weft tensile strength obtained with acid as compared with soap milling, of 28-oz. Admiralty great-coat twill cloth. (C)

Antiseptics for Textile Purposes. Robert A. Engel and Dr. William Gump. *Am. Dye. Rptr.*, March 31, 1941, V. 30, No. 7, P. 163–5. (C)

Casein and Staple Fiber Yarns: Properties. W. Davis. *Hosiery Tr. J.*, 1940, V. 47, No. 564, P. 32–3.

A series of tests on knitting yarns and fabrics composed of Courtaulds' casein fiber and Fibro respectively and of mixtures of these in various proportions, show that increase in percentage of casein fiber results in a decrease in tensile strength and extension of the yarn and in resistance to abrasion of the fabric. (C)

Development of Substitutes for Foreign Textiles Used in Parachutes. Joshua Miller. *Rayon Text. Mo.*, March 1941, V. 22, P. 70–72. (C)

Electrocoated Pile Fabrics. N. E. Oglesby and L. E. Hoogstoel. *Am. Dye Rptr.*, March 17, 1941, V. 30, No. 6, P. 156–58. (C)

Fiberglas Decorative Yarns and Fabrics. *Am. Dye. Rptr.*, March 3, 1941, V. 30, No. 5, P. P115–P118. (C)

Formaldehyde Treatment for Finishing Cotton and Rayon Fabrics. A. J. Hall. *Canadian Text. J.*, 1941. I. March 14th, V. 58, No. 6, P. 34–6. II. Crease Resistant Fabrics. April 11th, V. 58, No. 8, P. 35–8, 50.

The scientific background and works methods for finishing cotton and rayon fabrics with increased resistance to shrinkage and creasing through the use of formaldehyde to combine with the cellulose of cotton and rayon fibers. (C)

Methods of Measuring the Effect of Spinning Agents on the Conductance and Friction Characteristics of Wool. Colver P. Dyer. *Am. Dye. Rptr.*, March 3, 1941, V. 30, No. 5, P. P119–P122. (C)

III. Chemical and Other Processing (Not Otherwise Classified)

Actual Considerations on the Treatment and Dyeing of Wool. C. Thibaud. *Teintex*, V. 5, P. 141–3 (1940); abs. in *C. A.*, V. 34, Col. 6080.

(1) All pH values cause reactions corresponding to that of the fiber for that value; (2) the reaction is best when the ratio of the bath vol. is 1:100; an increase in this ratio does not aid the reaction; (3) the pH must be accurately controlled; (4) changes in pH will alter the absorption of dye; (5) dyeing must never be tried with a pH less than 1.3. The resulting dyed wool can be considered a protein salt of the dye. The following conditions are important: (a) choice of dyes that react best with the basic protein groups of the wool, (b) uniform distribution and absorption of the dye by mech. agitation to prevent impoverishment of the dye in the vicinity of the fibers, (c) using very little acid at the beginning, (d) keeping the temp. low to favor penetration of the dye, then raising the temp. and the acid concn. to activate the basic groups of the wool, thereby causing a better reaction with the dye. (C)

Ammonium Carbonate as a Substitute for Calcined Soda. V. Golosov and Yu. Ivanova. *Sherstyanoe Delo*, V. 17, No. 5, P. 73–6 (1938); *Chem. Zentr.*, 1938, II, 2864–5; abs. in *C. A.*, V. 34, Col. 6086.

Expts. reported indicate that the calcined soda can be partially or entirely replaced by $(NH_4)_2CO_3$ in the fulling and washing processes. In this way the salt and cystine linkages in the wool fibers are less strongly attacked. When the fat content of the raw material is 8%, $(NH_4)_2CO_3$ is used in 2–3% soln. in the fulling process. When the fat content is less than 8%, the Na_2CO_3 can be completely replaced by $(NH_4)_2CO_3$, although the soap soln. must be cooled to 30°. The soda can be completely replaced by $(NH_4)_2CO_3$ in the washing process. (C)

Association between Fibers and Dispersed Particles. C. L. Wall. *Text. Mfr.*, 1940, May, V. 66, P. 202–3, 208; June, P. 245; July, P. 286–7; August, P. 321; Sept., P. 359–60; abs. in *J. T. I.*, Nov., V. 31, P. A611.

IV. Discusses the energies between dispersed particles and their influence on aggregation theoretically and in known results. V. The author has extended his exposition of the relations between molecular structure and the properties of fibers to a consideration of the association between fibers and dispersed particles. The influence of polarization of groups in the dye molecule is discussed with a number of practical illustrations. (C)

Bleaching and Dyeing of Jute. M. R. Fox. *Text. Recdr.*, V. 57, P. 34–5 (Apr. 1940); abs. in *C. A.*, V. 34, Col. 5285.

A tech. description of the bleaching process and of the choice and application of the various types of dyes. Rotting can be prevented by metallic soaps such as oleates and naphthenates of Cu and Zn. Another method consists of treatment in a slightly alk. soln. of 40% HCHO. Creosote has the disadvantage of bad odor. The choice of dyes is important. *Ibid.*, 30–1

(May 1940). If jute is treated with cold concd. solns. of NaOH it begins to swell, shrink and change color. The resultant fiber on rinsing and neutralizing is elastic, softer and more fluffy than originally and resembles wool in many ways. In this condition the jute can be carded along with wool and excellent yarns and piece goods made from it. Woolenized jute has an increased affinity for most dyes. Acid colors and substantive colors give increased color value on the new product. Basic and S dyes give slightly stronger results, while most chrome dyes have low affinity. (C)

CELLULOSE ETHER FINISHES FOR TEXTILES. J. Andrew Clark. *Am. Dye. Rptr.*, 1940, V. 29, No. 21, P. 549–50. (C)

DEGREE OF MERCERIZATION AND ITS MEANING. F. G. Brown. *Text. Col.*, Sept. 1940, V. 62, P. 587.

The author explains this article covers a somewhat new way of looking at the mechanism, effects and extent or measure of mercerizing. It is very largely based on the German of W. Schramek and H. Thomas. Many of the observations discussed are already familiar but the interpretations represent a chemical viewpoint which has not always been accepted, and at present is probably not completely accepted. (C)

THE DEPENDENCE OF THE DYE ABSORPTION POWER OF VISCOSE FIBERS ON THE EXTENT OF STRETCHING. P. Eckert, H. Riedel and C. Catzin-Besserer. *Zellwolle, Kunstseide, Seide*, V. 45, P. 33–5 (1940); *Chem. Zentr.*, 1940, I, 3025–6; abs. in *C. A.*, V. 34, Col. 5284.

The dye-absorption power of the textile for various substantive dyes such as Diamine Black BH, Benzogreen C, and Benzobrown G decreases with increased stretching. (C)

DYEING OF NUANCES ON WHITE. F. J. Robert. *Tiba*, V. 17, 619–21 (1939); abs. in *C. A.*, V. 34, Col. 5664.

Nuances on white fabrics are produced by bleaching in reducing or oxidizing baths. The process is aided by tinting with dyes to produce different qualities of white, varying from beige to bluish white. The best bleaching action is obtained by peroxides such as perborate or H_2O_2. Cl or SO_2 is more economical but the former is only used for vegetables fibers. Wool and silk are bleached in a very mild, alk. bath contg. Na_2HPO_4 or Na_2SiO_3. Vegetable fibers are bleached in a bath contg. Na_2CO_3. Vat dyes are used for fast shades. The dyes are dispersed in soap baths from which they are absorbed by the fabrics in small quantities. (C)

THE "GRADED-TEMPERATURE PROCESS," A NEW AND SIMPLE METHOD FOR DYEING VAT COLORS ON CELLULOSE FIBERS. Drapal. *Mell. Textilber.*, V. 21, 294–5 (1940); abs. in *C. A.*, V. 34, Col. 5665.

A previously described procedure (*Ibid.*, V. 21, 179–80 (1940) gives good leveling with all Indanthrenes except those of the IN series. For these the vat is made up in the usual manner and cooled to 15–20° C. at which temp. dyeing is started. The temp. is raised 1° per min. to 35°, and then at the ordinary rate to 50–75°. Good leveling is obtained despite the high affinity of the dyes for rayon. (C)

IV. Research Methods and Apparatus

Absorbent Cotton. O. Eichler. *Mell. Textilber.*, V. 20, P. 429–32, 503–6, 641–2, 705–6, 751–8, 800–3, (1939); abs. in *C. A.*, V. 34, Col. 8290 (1940).

Methods of prepg. and testing absorbent cotton (AC) were studied critically and are described. (C)

Comparison of the Breaking Strength of Fabrics as Determined by the Pendulum and Incline Plane Testing Machines. Gladys White and Emma C. Petersen. *Rayon Text. Mo.*, Dec. 1940, V. 21, P. 69–70; Jan. 1941, V. 22, P. 70–1. (C)

The Determination of Iron and Chromium in Cotton. M. E. Probert and M. B. Paterson. *J. T. I.*, Nov. 1940, V. 31, P. T231–T234. (C)

How to Analyze Tricot Fabrics. Otto Engelhard. *Rayon Text. Mo.*, Dec. 1940, V. 21, P. 71–2. (C)

Laboratory Scouring Apparatus. W. Garner. *Analyst*, 1940, V. 65, P. 563–4; abs. in *J. T. I.*, Dec. 1940, V. 31, P. A676.

A simple form of apparatus for the scouring of textile materials is described. (C)

Methods for the Determination of the Durability of Cotton Fabrics. B. P. Pozdnyakov. *Legkaya Prom.*, V. 16, No. 10, P. 35–53 (1937); *Chem. Zentr.*, 1938, II, 1157; abs. in *C. A.*, V. 34, Col. 5286. (C)

The Microscope in Textile Analysis. Wm. O. Holmes and F. J. Munoz. *Rayon Text. Mo.*, Jan. 1941, V. 22, P. 77–79; Feb., V. 22, P. 70–2, 74. (C)

New Porosity Tester. *Rayon Text. Mo.*, Jan. 1941, V. 22, P. 92.

This is a porosity tester, or "Air-Flo Meter" developed in the laboratories of The B. F. Goodrich Company, Akron, Ohio, for special use in testing its Air-Cell latex sponge products. The instrument indicates the relative rate of air that can be drawn through a porous material under given conditions. (C)

Quantitative Determination of Indigo on the Fiber. J. Lotichius. *J. Soc. Dyers Col.*, Oct. 1940, V. 56, P. 435. (C)

Some Methods for Determining the Solidity of Yarns and the Possibilities of Their Application. Stig. Kjellstrand. *Skand. Tid. Textilind.*, V. 37, P. 6–8, 31–5, 92–4 (1939); abs. in *C. A.*, 1940, V. 34, Col. 8289.

A review on some fundamental ideas and on methods for detg. homo- and inhomogeneity, tensile strength, energy and extensibility of yarns, for continuously testing long yarns, and for finding av. values of the solidity of cotton, flax, jute, worsted and rayon yarns. (C)

V. Pure Science, Economics and Misc.

Analysis of Olive Oil. S. Fachini and G. B. Martinenghi. *Olii Min. Grassi*, 1939, V. 19, P. 86–88 (through *C. A. B.*, 1940, V. 59, P. 374); abs. in *J. T. I.*, July 1940, V. 31, P. A417.

The oil is treated with acetic anhydride and sulphuric acid; a red color (due to resinous matter) indicates addition of olive husk oil, which is also indicated by the Bellier test for arachis oil, while if it is refined it is detected by a positive test for CS_2 (used as solvent) by the Cu xanthate reaction. (C)

The Behavior of Cellulose in Solutions of Alkalies. X. The Behavior of Cellulose in Mixtures of Alkalies. Gi-iti Saito. *J. Soc. Chem. Ind., Japan*, V. 43, Suppl. binding 126–7 (1940); cf. *C. A.*, V. 33, 7096; *Ibid.*, V. 34, Col. 6063. (C)

Cellulose Acetate: Degradation. H. Mark and R. Simha. *Trans. Faraday Soc.*, 1940, V. 36, P. 611–18; abs. in *J. T. I.*, July 1940, V. 31, P. A415. (C)

Dyes for the Preservation of Fine Nets and Webs. Ya. D. Borodulin. *L'no-Pen'ko-Dzhutovaya Prom.*, V. 8, No. 1, P. 37–43 (1938); *Chem. Zentr.*, 1938, II, 2047–8; abs. in *C. A.*, V. 34, Col. 5283.

The protective action of individual dyes against the growth of microflora on fish nets was studied. The dyed nets were left in sea water for 90 days under conditions prevailing in fishing. Alizarin-2, Indanthrene Brilliant Green W, Anil Copper Blue B, and aniline black showed the best protective action. Abil Brown DZG and Basic Brilliant Green (on tannin) were also valuable in fresh water. The protective action of the substantive dyes was improved by admixt. of salts of heavy metals, as $CuSO_4$, $Hg(NO_3)_2$ and $Pb(OAc)_2$. For indanthrene dyes, subsequent treatment with tar emulsions improved the action, especially in the case of nets in fresh water. The protective action of the dyes is due to the presence of toxic groups in the mol. and not to the presence of salts of heavy metals. The protective effect of aniline black, Alizarin-2, and of Anil Copper Blue B is much greater even than tanning and sometimes greater than the protection afforded by treatment with coal tar. (C)

The Heats of Adsorption and Wetting of Mercerized Celluloses by Sodium Hydroxide Solutions, Water and Methyl Alcohol. J. L. Morrison, W. Boyd Campbell and O. Maass. *Can. J. Rsch.*, V. 18, B, 168–79 (1940); *J. Soc. Dyers. Col.*, Oct. 1940, V. 56, P. 450; cf. *C. A.*, V. 32, 7718; *Ibid.*, V. 34, Col. 6063. (C)

Infrared Photography. E. Schwarz. *Photo Technique*, February 1940, V. 2, P. 8–11; abs. in *Eastman Kodak Abs. Bull.*, October 1940, P. 521.

The effects obtainable with infrared film are outlined and the method of using is described. Dramatic effects are obtained when the film is used with a blue-absorbing filter. When no filter is used, the results are similar to those obtained with regular panchromatic film. (S)

INTERATOMIC DISTANCES IN PROTEINS AND RELATED SUBSTANCES. R. B. Corey. *Chem. Reviews,* April 1940, V. 26, P. 227–36; abs in *Eastman Kodak Abs. Bull.,* August 1940, P. 440.

In a survey of protein structures, it is pointed out that the α-keratin β-keratin transformation is an incomplete explanation of the extension of certain protein fibers; the existence of a closed ring structure of the α-form is, in the light of recent evidence, very improbable. The latest figures on interatomic distances in proteins are listed. (S)

INTERMICELLAR HOLE AND TUBE SYSTEM IN FIBRE STRUCTURE. H. Mark *J. Phys. Chem.,* 1940, V. 44, P. 764–88; abs. in *C. A.,* 1940, V. 34, Col. 5655.

A crit. summary of the implications of recent x-ray diffraction and optical studies of the structure of cellulose, including some comparisons with *rubber.* Phys. properties are correlated with the degree of crystallinity. 118 references. (C)

MACROMOLECULAR COMPOUNDS. CCXXXVII. THE DESTRUCTION OF CELLULOSE BY MICROÖRGANISMS. H. Staudinger, M. Staudinger and H. Schmidt. *Zellwolle, Kunstseide, Seide,* V. 45, P. 46 (1940); cf. *C. A.,* V. 34, 2588; *Ibid.,* V. 34, Col. 6063. (C)

MOTHPROOFING: PRESENT STATUS OF. Henry F. Herrmann. *Am. Dye. Rptr.,* 1940, V. 29, No. 21, P. 539–540. (C)

A NEW METHOD FOR INVESTIGATING THE REFRACTIVE INDEX AND THE THICKNESS OF THIN INTERFERENCE FILMS ON GLASS. A. Vasicek. *Phys. Rev.,* May 15, 1940, P. 925–31; abs. in *Eastman Kodak Abs. Bull.,* July 1940, P. 381.

If plane-polarized light falls on lead glass the surface of which has been chemically changed to be covered with an interference film, the reflected light is, in general, elliptically polarized. If, however, the path difference of reflected rays from the air-film boundary and from the film-glass boundary is $2n_0 d \cos r + \frac{1}{2}\lambda = k\lambda$, where k gives the order of the maximum, the first maximum for $k = 1$ being $d(n_0^2 - \sin^2\phi)\ \frac{1}{2} = \frac{1}{4}\lambda$, and where n_0 is the refractive index of the film, d is its thickness, ϕ is the angle of incidence, r is the angle of refraction, and λ is the wave length of the monochromatic light, then the reflected light is plane-polarized. For this angle of incidence ϕ, the plane of polarization of the reflected plane-polarized light will be the same as if the polarized light were reflected from an ideal surface of glass (not covered with a film). From the angle between the plane of polarization of the analyzer and the plane of incidence, the refractive index of the glass, n, can be calculated according to the formula deduced from Fresnel's relations: $n^2 = \sin^2\phi\ [1 + \mathrm{tg}^2\phi\ \mathrm{tg}^2\ (\psi + 45°)]$, where ϕ is the angle of incidence, ψ is the angle between the plane of polarization of the analyzer and the plane of incidence (the angle between the plane of polarization of the polarizer and the plane of incidence is 135°). The refractive index, n_0, and the thickness d of the surface film can be calculated from the formula for the maxima if two angles of inci-

dence ϕ_1 and ϕ_2 are determined for two different wave lengths. The refractive index of the film n_0 is given by the formula:

$$n_0 = \left(\frac{\lambda_1^2 \sin^2 - \varphi_2 - \lambda_2 \sin^2 \varphi_1}{\lambda_1^2 - \lambda_2^2}\right)^{\frac{1}{2}}.$$

The results of the measurements are given in tables. (S)

ORIENTATION OF LIQUID CRYSTALS BY HEAT CONDUCTION. G. W. Stewart, D. O. Holland, and L. M. Reynolds. *Phys. Rev.*, July 15, 1940, V. 58, P. 174–76; abs. in *Eastman Kodak Abs. Bull.*, September 1940, P. 496.

A new phenomenon in heat conduction is described in which "liquid crystals" of para-azoxyanisol become oriented under the action of heat conduction in the liquid. A temperature gradient of 1° or 2° C. per centimeter is found to be sufficient to orient the crystals if the temperature of the whole liquid is at 125° C. The orientation of the crystals is determined by x-ray diffraction. (S)

THE PHENOMENON OF FLUORESCENCE. Henry E. Millson. *Am. Dye. Rptr.*, 1940, V. 29, No. 22, P. 579–582. (C)

PROTEIN FIBRES. W. Grassmann. *Atti X° congr. intern. chim.*, 1939, V. 4, P. 753–54 (through *C. A.*, 1940, V. 34, Col. 3126); abs. in *J. T. I.*, July 1940, V. 31, P. A417.

Most protein fibres have many structural modifications. Their molecular orientation can best be determined by X-ray technique. Shrinkage of collagen fibres by heating with water can be measured by X-rays and by enzymic action. Crude fibres are not attacked by enzymes, while fibres that have been shrunk by exposure to heat are readily digested by enzymes. Hydrogen ions favor shrinkage while hydroxyl ions have no effect. Tannins reduce shrinkage and strengthen the fibres. Heat treatment of collagen fibres in stretched condition prevents subsequent shrinkage. Chemical analysis of fibrous proteins points to chain linkages of amino acids with similar type amino acids recurring frequently. The amino acids of the collagen molecule stand to each other in a simple numerical ratio. (C)

THE VISCOSITY OF CELLULOSE TRIACETATE SOLUTIONS IN ETHYLENE CHLORIDE-METHANOL MIXTURES. K. Seki. *J. Soc. Chem. Ind.* (Japan), June 1940, V. 43, P. 165B; abs. in *Eastman Kodak Abs. Bull.*, November 1940, P. 585.

Fibrously acetylated cellulose triacetate was dispersed in a mixture of ethylene chloride and methanol (10 to 15 per cent methanol) at 50° to 60° C. to form an approximately 20 per cent dope. The dope viscosity was determined at 25°, 30°, and 35° C. as a function of time, and qualitative studies were made of the gelation point of this system. The temperature at which gelation occurs is higher, the greater the concentration of the dope and the higher the degree of polymerization of the cellulose triacetate molecule. In dilute solutions, precipitation rather than gelation occurs when the temperature is lowered sufficiently, and this is accompanied by thixotropy. (S)